A Framework for Managing Software Testing Outsourcing Projects

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***Abstract*—Software testing aims to ensure that the software produced is reliable and able to function correctly. In order to do so, the testing execution requires experts and technology that might not be available within an organisation. Therefore, shifting to outsourcing for testing is one preferred option. This alternative provides benefits such as testing expertise, costs and time reduction, better testing technology and high-quality software products. Translating these benefits into practice has, however, proved challenging. Some testing outsourcing projects have failed outright. These projects either exceed the specified time or the allocated budget or failed to deliver the anticipated quality. This paper therefore intends to address this concern by providing guidance in managing software testing outsourcing projects in the form of a framework based on identified success factors. Previous studies have collected the success factors from theoretical and empirical perspectives. The investigation continues by ratifying the factors via software testing and project management experts from both the client and vendor sides. In order to develop the framework, this study adopted a qualitative approach, in which semi-structured interviews were employed to confirm the factors. The data were then analysed using content analysis. The framework consists of two aspects, namely People and Process. Four factors make up the People aspect, while another ten constitute the Process aspect. Each factor contains elements, which represent either the roles that should be played or activities that should be conducted. This framework contributes to the understanding of conducting successful software testing outsourcing projects. It could also act as a reference for future research in the software testing domain.**

***Index Terms*—Outsourcing; Project Management; Software Testing.**

I. INTRODUCTION

Software testing is an assessment process that ensures software is developed to an acceptable quality. The process provides layers of defect filtration so that the software exercises its functions properly according to its predetermined context [1, 2]. It is believed that software testing directly influences the success of the software. A better software testing process results in a better software product.

As the usage of software becomes more rampant and is more habitually used in critical and intricate application domains, the execution of the software testing process also becomes increasingly imperative. The process would become more costly and complex, requiring greater quality and reliability. Therefore, delegating the work to external parties would be an appropriate alternative to meet these demands. Through outsourcing the testing process, organisations will have the opportunity to focus on their core activities [3, 4], enjoy more reasonable costs [5] and reduce project durations [6] without compromising project quality.

Achieving these benefits however is not always straightforward. Project failure still occurs. This includes projects that are not delivered on time, the quality produced does not meet the quality thresholds, and anticipated benefits such as cost saving are not achieved [1]. In principle, testing outsourcing projects are more likely to produce good results if they are executed according to certain success factors [7-11]. Unfortunately, these success factors are discussed independently, scattered and appear in silos or specific viewpoints [12, 13]. Moreover, most success factors are only relevant to outsourcing projects in general with less focus to software testing context [9, 10, 14, 15]. In fact to date, there is no integrated view that visualises the success factors as roles and activities between the testing vendor and client. Hence, the participating parties of such projects are often unguided in managing software testing outsourcing projects and finally, they fail. Therefore, there is a need for specific guidance on managing software testing outsourcing projects.

This paper addresses the above-mentioned concerns by identifying the success factors specifically for managing software testing outsourcing projects. The success factors are presented in the form of a framework. The framework is derived through of a series of studies. Initially, the contributing factors were gathered from theoretical [16] and empirical [17] studies. The results from both studies were then validated and confirmed by software testing and project management experts. This paper in particular discusses the validation process by the experts and the final findings, namely the framework.

This paper is organised as follows: Section 2 discusses the related work of software testing outsourcing. Section 3 presents the research methodology used in the study. Section 4 discusses the findings and Section 5 explains the proposed framework. Finally, Section 6 concludes the work and suggests some future work in the area.

II. RELATED WORKS

Previous studies on software testing outsourcing have revolved around various issues and aspects regarding its implementation. This includes the influences of culture [7, 14, 18], role of the implementers as well their relationships [9, 19], management strategies [9, 20], and software outsourcing contract issues [4, 6, 15]. Besides that, the lessons learned from testing outsourcing projects [10, 21] and their challenges [1, 11] are also discussed.

Even though the advantages of software testing outsourcing are compelling, it is not practical for all organisations. Organisations need to justify the need to

implement such projects by understanding the projects' importance [14, 22]. They should also comprehend the project purpose clearly [11] and understand the nature of the project [22].

After making the decision to conduct testing outsourcing, strategies must be planned to anticipate any uncertainty issues [20]. This effort includes defining the goal and objectives [11, 23], estimating the schedule [11], and specifying the infrastructure [6] and human resources needed [20, 24]. A contingency plan should also be drafted carefully to handle any risks that might occur [12, 20]. The work scope should be defined clearly in order to avoid vague work delegations that would cause project delay [25]. The cost estimation should be stated in specific as well [20]. Besides that, the determination of test work priorities [12] and appropriate test parts to outsource should be set in advance [4, 6].

Hiring a qualified vendor for testing outsourcing is important in producing high quality testing work. In this sense, it is crucial that the testing vendor possesses the required domain knowledge [10, 23] and technical skills 10, 22]. The vendor should also own recognizable reputation and set capabilities [22]. Besides that, the vendor should have low turnover rate and sufficient skilled personnel [4, 6]. Insufficient human resources could lead to excessive workload, which will affect testing work quality and prolong its duration. The selected vendor must also be free from any political disturbance whether it be organizational or national issues [7, 26]. Another important aspect is the language [27] and culture [18] of the vendor. This is critical as the inability to acquaint with work culture and language could result in misinterpretation of information and affect communication.

A contract is a document, which specifies the services to be delivered and received by both parties involved. As such, the contract should be as comprehensive as possible [23]. This includes articulating the scope, objectives, project schedule, statement of work, cost and the authorized person for the tasks specifically. Besides that, the contract should be negotiable, as technology keeps evolving over time [21, 22]. It would also be beneficial if the contract is made on a short-term basis [22]. This allows regular reviewing of the work performed by the testing vendor, where changes could be done if necessary. The contract must also be aligned with the project needs and plan [14]. This is important to ensure that the project goal is achieved and the risks are handled strategically.

As testing outsourcing projects involve geographical distance, it is crucial that the infrastructure setup be prepared before testing activities are executed. Previous studies indicate that connectivity and network [6], information security [6, 20, 22], version control [28, 29] and digital or physical storage setup [1, 28] are among the required infrastructure. An efficient infrastructure configuration is important to ensure smooth knowledge transfer between the participating organizations and that the right information is conveyed [9, 13].

There are some preparations that need to be done before testing activities could be started. For example, testing activities must first be planned. This must be taken into account throughout the testing process [30]. In the test plan, the work duration, job, and responsibility of the testers must be determined in accordance with the project goal. Apart from that, developing the test design [30, 31] and determining the test tools and procedures [28, 32] are also essential in the preparation effort. The test design is required for the testers to specify and plan the methods to be used to execute the planned test. Besides that, the appropriate test tools and systematic procedures are necessary, as these will be beneficial in improving the testing process [32].

At the start of the testing process, several elements must be taken into consideration. For instance, the testing process must be continuously controlled [31]. Testers should monitor their progress to ensure the tasks are completed according to the project schedule. They should also make sure that the project milestones are achieved. Besides that, the predetermined test criteria must also be fulfilled [33]. This will prove beneficial in determining the level of testing that has been completed so far and to ensure that the testing process is executed correctly [33]. Reporting the testing status is also crucial in assessing the current project progress and in considering any necessary follow-up actions [31]. Aside from the testing team, the clients should also play a part in monitoring the testing progress. For instance, on-going discussions [34, 35], regular visits [6], tracking the project progress [34] as well as placing representatives at the vendor's site [34] should be practiced. Through monitoring, any issues that occur could be handled immediately before they become worse.

After the testing activities have been completed, the activity outcomes need to be reported to the client [36]. The outcomes are evaluated through quality assessment in order to determine whether or not the test has achieved the project objective. Any project artefacts produced throughout the project such as test tools, test logs, defects analysis, test results, and test cases need to be returned to the client [1]. The project artefacts are returned to protect the client's right as these artefacts were built using client information. The evaluation of vendor performance should also be carried out [1]. This information would be beneficial as reference in deciding potential testing vendors for future projects.

The management also plays an important role in software testing outsourcing projects. The Top Management should support the project by ensuring that the progress is executed according to the organizational directions and objectives [11]. The Project Manager should possess interpersonal skills because he or she needs to handle people of different cultures, languages and time zones when executing the project [19, 24]. The Project Team and the Test Team should also show commitment [37, 38], trust [13], and build partnerships [21, 39] with each other. Both teams should possess good communication skills [11] in order to avoid any misunderstanding during the execution of the project. Since the testers are responsible for conducting the testing processes, they should also have relevant domain knowledge [10, 23] and technical skills [10, 22] as these criteria contribute to better testing performance.

The factors that need to be considered in managing software testing outsourcing projects were determined from past studies [16]. These factors were then confirmed empirically by five practitioners in the testing industry [17]. In order to develop a solid framework of the subject matter, the proposed factors and elements need to be further strengthened through experts' validation.

III. RESEARCH METHODOLOGY

The purpose of this paper is to present a framework as guidance for testing practitioners in managing software testing outsourcing projects. In general, this study aims to

answer the following research questions (RQ):

RQ1: What are the contributing success factors in managing software testing outsourcing projects?

RQ2: How can these factors be combined to form a framework for managing software testing outsourcing projects?

Several success factors were identified via the theoretical study conducted earlier [16]. The contributing factors were then further confirmed by testing practitioners through the empirical study [17]. As the research objective concerned in this paper is to validate the gathered success factors, the study extended the effort by gaining validation from the experts to affirm the factors (Research Question a) and the interconnection between the factors to form a framework (Research Question b).

In order to develop the framework, a qualitative approach was used. This approach was chosen as it allows the researchers to acquire a deeper understanding and more detailed information of the study [40]. It is also beneficial in gaining profound insights into factors that contribute to the better management of testing outsourcing projects. Figure 1 illustrates the research design, which contains the main activities involved in the study. The following sections explain the activities in each phase.

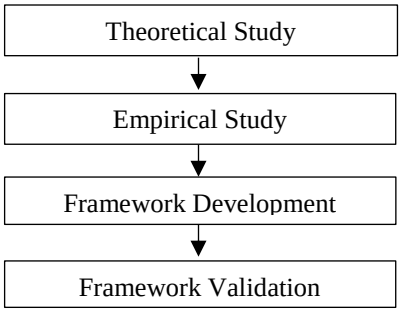

Figure 1: Research Design

A. Theoretical Study

The theoretical study was the preliminary stage for gaining an understanding of software testing outsourcing issues and to figure out the research background. The aim of this phase was to identify the contributing factors in software testing outsourcing projects by reviewing past studies. The output of this phase is illustrated as a model concept, explained in [16].

B. Empirical Study

The empirical study was conducted to confirm the factors that were discovered earlier in the theoretical work as well as to gather new factors or elements. During this phase, several experienced practitioners from the software testing industry were interviewed. The practitioners' viewpoints are crucial for verifying the practicality and existence of the identified factors in real-world settings. It is also important to acquire further explanation of the elements in each factor. The interview findings are discussed in [17].

C. Framework Development

Based on the findings from the previous two studies, a framework was developed using the content analysis method. The proposed framework is depicted in the form of aspects, factors and elements mapping, which will be discussed in detail later.

D. Framework Validation

In order to appraise the proposed framework, evaluation by experts is needed. The experts are credible and experienced in the domain. Their inputs are required to improve and strengthen the proposed framework. In the study, the evaluation covered feasibility and accuracy aspects. The feasibility aspect assessed whether or not the factors and elements are practical and usable in the testing industry. Meanwhile, the accuracy aspect was assessed in terms of the correctness and relevancy of the concepts—factors and elements—being used. Besides that, the interrelationships between the factors and elements in the proposed framework were also affirmed. The following paragraphs elaborate the expert validation or review sessions that were carried out.

1) Data Collection

To conduct expert review sessions, the right and suitable experts in the field have to be identified. To achieve this objective, purposive sampling was adopted. Purposive sampling is a sampling method for choosing a group of informants that have the designated criteria based on the research needs [40].

Through purposive sampling, several experts from the Government and Private sectors in the testing industry either from the client or vendor company were selected. Aside from specializing in the area of software testing outsourcing, the selection was also made based on the years of working experience. All the experts are senior officers who have served more than 10 years. As for the sample size, the number of experts to be interviewed was not predetermined. The selection was carried out continuously until the information obtained from the experts reached the saturation level.

The proposed framework was presented to five experts, in which three of them being from the Government sector and the other two from the Private sector. The experts were interviewed individually at their respective workplace for about one to two hours. At the beginning of the session, the experts were briefly explained about the research background, the purpose of the study and their roles. The interview sessions were audio recorded upon their consent. The data from the recorded interviews were then transcribed into text format and later analysed for interpretation. Table 1 briefly outlines the profiles of the five experts.

2) Data Analysis

The data were analysed using the content analysis method [41]. Content analysis is a qualitative research method used to analyse data—whether it be in the form of written, verbal or visual communication messages—into a much more categorised and simpler form that is easier to understand [41]. The categorisation of the content analysis is made through the consideration of common context, words, and phrases, which have the same meaning. In this study, the content analysis approach was executed through the four main steps below:

a) Defining the data types and samples involved

Data from both the theoretical and empirical study were gathered from the designated samples. The former came from the literature whereas the latter from the practitioners. The theoretical data were defined based on the written text. On the other hand, the empirical data were defined by firstly listening to the recorded audio and transcribing them into raw data in text format.

b) Defining the main concept of the data

The raw data were categorised into specific concepts based on the meaningful attributes in the data content. The process was done continuously until there was no more data possessing the same meaning in the data content. The process was carried out continuously throughout the analysis.

c) Constructing the coding scheme according to the study needs

The categories were indexed according to their appropriate definitions of the study needs. In the study, it is based on aspects, factors or elements.

d) Explaining the findings and their relationship

The defined categories were mapped into aspects, factors and elements as well as their relationships in the framework. The identified factors and elements were categorised into two main aspects, which are Process and People. The People aspect consists of four factors, namely Top Management, Project Manager, Project Team, and Test Team. Each factor in the People aspect is responsible in managing activities in the Process aspect.

The Process aspect encompasses four phases, which are Pre-Implementation, Preparation, Execution, and Post-Implementation. There are ten factors in this aspect. The factors are Needs Identification, Project Planning, Vendor Selection, Contract Establishment, Infrastructure Setup, Testing Needs Setup, Testing Execution, Project Monitoring, Testing Evaluation, and Project Close-Out.

Table 1
List of Expert's Profile

Criteria	Organisation	Position	Experience (Years)	Sector	Areas of Expertise
Expert 1	Tester	Testing Consultant	Exceeding 10	Private	Application System
Expert 2	Client	Senior Manager	Exceeding 15	Government	Electronic Government System
Expert 3	Tester	Test Lead	Exceeding 10	Government	Application System
Expert 4	Tester	Test Manager	Exceeding 10	Government	Application System
Expert 5	Client	Project Manager	Exceeding 15	Private	Application System

IV. RESULTS

The experts agreed and confirmed most factors and elements in the proposed framework. Thus, those factors and elements are not discussed in this paper, as they have been elaborated in earlier study [17]. This section only reports the modification and suggestions obtained through the expert review sessions. The experts provided some recommendations for improvement, either to relocate the element's position, add new elements, or subtract elements from the proposed framework. The suggestions are categorised according to two main aspects, which are People and Process. The following sections list the comments and suggestions from the experts on the proposed framework:

A. People

The expert clarified that the Project Manager is the one responsible for identifying the project needs in order to execute the project. In the initial proposed framework, this matter was not stated in detail and this led to the assumption that the responsibility is carried out particularly by the Top Management. Therefore, the expert suggested that it must be stated clearly that the Project Manager must assume the role of handling elements in the Needs Identification factor.

"It is understood that the Top Management has the accountability to identify the reasons, purpose, and also to understand the needs for testing outsourcing projects. However, the Top Management is not specifically liable operatively for this matter. Defining the responsibility of the Project Manager against the Needs Identification factor will help clarify the role and duty of the Project Manager and Top Management." – Expert 5

B. Process

The recommendations in this aspect involve elements in three phases, which are Pre-Implementation, Execution, and Post-Implementation.

1) Pre-Implementation Phase

There are four elements that need to be revised in this phase: Allocate Cost and Determine Scope of Work in the Project Planning factor, Specify Culture Compatibility in the Vendor Selection factor, and Specify Short-Term Contract in the Contract Establishment factor.

a) Allocate Cost

The experts agreed that Allocate Cost is one of the important elements in Project Planning. Hence, the experts have given a few suggestions in clarifying the cost allocation for software testing outsourcing projects as below.

"*Generally, cost is charged based on how we execute the project, whether it be a conventional or specific testing service-based project. For a traditional or conventional project, the cost is determined based on how much human resources is needed, testing process duration or for how long the testing tools are required. On the other hand, some testing vendors also offer a package price for specific testing services. This is determined based on the requirement cost to do the testing. This includes the testing tools needed or the scope of the project.*" – Expert 3

"*We also need to consider the tester's level of expertise. For example, the price charged for an experienced tester would definitely be higher compared to another who does not have that many years of experience.*" – Expert 4

b) Determine the Scope of Work

Aside from agreeing that the work scope determination is important in Project Planning, some suggestions have also been given by the experts on how to determine the scope in testing outsourcing projects:

"*The scope for testing outsourcing projects should be defined properly to make sure that the project objective is fulfilled. The determination of the work scope could be done by considering the level of software development, for instance, by using the V-model. The model could be used as a reference, as it shows the relationship between the development and the testing involved*." – Expert 2

c) Specify Culture Compatibility

In the initial proposed framework, this element was

excluded as it was not supported by most informants during the empirical study. However, the experts clarified that working culture compatibility among participating organisations is actually essential, particularly for outsourcing that involves different countries. The understanding of vendor working culture is important in creating good cooperation and relationships.

"*Actually, the compatibility in working culture is important especially for projects that require collaboration from different countries. There are some organisations that do not face this problem, as long as the people involved are able to deliver good cooperation. For example, some organisations are more open to admitting their mistake or incapability of handling tasks. However, there are some organisations that are not inclined to discuss these issues. This could cause a much bigger problem as the project goes on. Therefore, in making the vendor selection, we need to ensure that the possible vendor is more mature in handling working culture issues*." – Expert 5

d) Specify Short-Term Contract

This element was not supported by most informants in the empirical study. During the reviews, the experts informed that the contracts for testing outsourcing projects are normally short-term, set according to work progress in order to drive the completion of the project. Due to that respect, the experts advocated this element to be excluded from the framework. It should not be considered as one of the contributing elements, as it is so common to have short-term contracts in testing outsourcing projects.

"*Normally, testing outsourcing projects are implemented in the short term. There are projects that take only two months to complete and the longest one would take two years*." – Expert 1

"*Testing outsourcing projects are not executed over a long time. This is because the contract is made according to smaller project scope or on a gradual basis. Say, after completing one test part for the project, a new contract will be constructed for the subsequent test part. Therefore, short-term contracts do not fit into the framework because it is just one of the practices of such projects*."– Expert 3

2) Execution Phase

There is one element that was added in this phase, which is the adoption of testing efficiency strategy. The experts claimed that conducting testing activities requires strategies. The Test Team needs to undertake the testing strategies vigorously, as failure to perform the test properly will affect the costs, resources, and time dealt with the client.

"*It is important to ensure that the software possess good quality. During the testing process, testers should have certain testing strategies to enhance the testing performance, for instance, by using efficient strategies. The testing process will be implemented in a more orderly and effective manner, which then saves time as well as producing a quality testing process*."- Expert 1

3) Post-Implementation Phase

In this phase, suggestions are made for three elements. The elements are Assess Passed Test, Conduct Test Closure, and Handover Testing Artefacts.

a) Assess Passed Test

The experts suggested the Assess Passed Test element to be added in the Testing Evaluation factor. In the initial proposed framework, this element was not mentioned clearly. The experts stated that the Fulfil Test Criteria element and Assess Passed Test element should be clearly distinguished. The passed test has to be shown as having been evaluated, as it contributes to the test results during the evaluation stage.

"*The aim of fulfilling the test criteria is not the same with that of evaluating the passed test, and thus these two elements should be distinguished. Therefore, it is more suitable to add the Assess Passed element to the Testing Evaluation factor. Results of the testing activities need to be evaluated to determine how many tests have passed the designed criteria*." - Expert 1

b) Conduct Test Closure Activities

The experts recommended the test closure activities to be added to the Project Close-Out factor. The activities are usually executed at the final stage of the project, which is after the software is tested.

"*Test closure activities should be conducted towards the project termination. Test closure activities will be executed when the testing process is completed. By adding the element to the Project Close-Out factor, it clearly indicates that the process is about to be finalised*."- Expert 1

c) Handover Testing Artefacts

The experts stated that returning the test artefacts back to the client should be executed in the test closure activities. Initially, this element was stated separately in the Project Close-Out. Therefore, the experts suggested that this element to be included together in the Conduct Test Closure Activities element as part of the Project Close-Out factor.

"*Handing the test artefacts back to the client is one of the activities conducted in the project closure activities. Therefore, it is more appropriate for this element to be included together with the test closure activities*" - Expert 1

V. DISCUSSIONS

This paper presents the finalised contributing success factors for managing software testing outsourcing projects. The factors were gathered and confirmed through three subsequent studies: theoretical; empirical and expert review.

The contributing factors are divided into two aspects, namely People and Process. The People aspect consists of four contributing factors, which are Top Management, Project Manager, Project Team, and Test Team. Meanwhile, the Process aspect consists of ten contributing factors. The factors are Needs Identification, Project Planning, Vendor Selection, Contract Establishment, Infrastructure Setup, Testing Needs Setup, Testing Execution, Project Monitoring, Testing Evaluation, and Project Close-Out. These factors are located in four subsequent phases, which are the Pre-Implementation, Preparation, Execution, and Post-Implementation phases.

Figure 2 illustrates the final framework that outlines the main factors, elements and their relationships with each other. The figure visualises the success factors as roles to be played and activities to be conducted between the testing vendor and client. The following paragraphs explain the framework in detail. As new elements are added to the final framework based on the experts' recommendations, some relevant references to support the statements are also included.

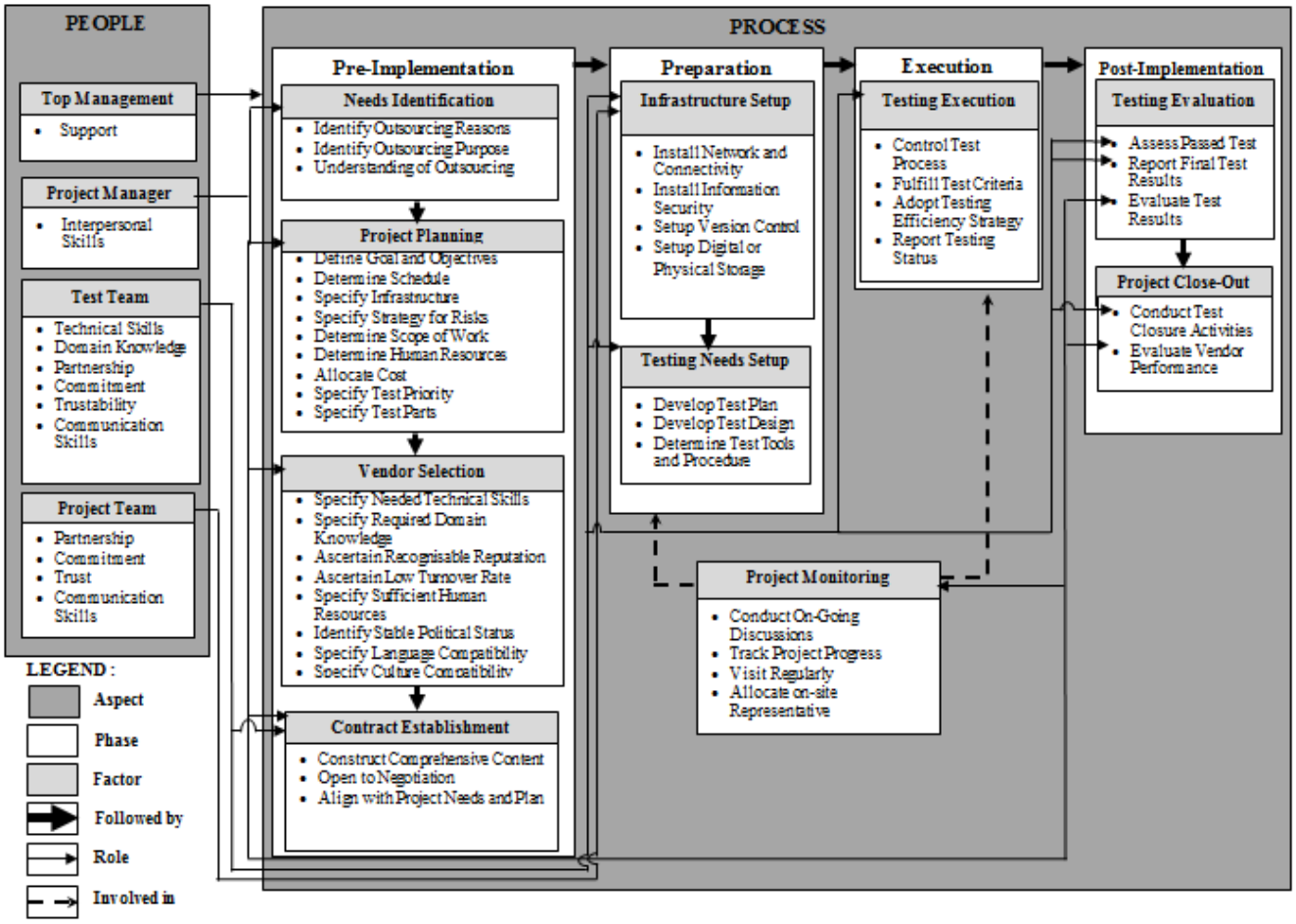

Figure 2: A Framework for Managing Software Testing Outsourcing Projects

A. People

The People aspect consists of the identified parties involved in the project and characteristics that they should possess in executing their responsibilities. They are the Top Management, Project Manager, Test Team, and Project Team. The Top Management, Project Manager and Project Team are the client whereas the Test Team is the vendor.

The Top Management is the highest-ranking executives, which manage the strategic direction of an organisation. The Top Management should be supportive and fully involved in the project. This effort is essential to encourage smooth project progress. Support from the Top Management could be demonstrated via the continuous monitoring of project progress through the Project Manager.

As for the Project Manager, one identified characteristic is that he or she must have good interpersonal skills, especially if the project requires collaboration from different countries. This means that the Project Manager needs to deal with vendors from different cultures and languages. Having good interpersonal skills is important for nurturing the cooperation between teams.

The Test Team consists of the people who are responsible for conducting the testing tasks. In order to deliver high quality test outputs, the Test Team needs to have technical testing skills and related domain knowledge. The Project Team comprises people who are responsible for handling the software development activities or for managing the outsourcing activities on the client side. The Project Team and Test Team work closely with each other and thus should have similar characteristics. For instance, both teams should practice partnership values in performing their jobs. Through the partnership, the Project Team and Test Team could tolerate and work together in handling any conflicts that might occur. They should also give full commitment towards each other. Commitment is essential to ensure that the tasks are executed well and the project is progressing according to schedule. As outsourcing projects require knowledge transfer, both teams should inculcate trust and trustworthiness. The Project Team needs to trust the Test Team's credibility in handling their assets, as the testing materials are shared with the Test Team. Similarly, the Test Team should also be trusted to guard such information. Through this effort, the process and tasks assigned could be simplified and run smoothly. Besides that, both teams should have good communication skills. Good communication skills are important to avoid miscommunication in conveying information and to nurture a strong relationship between both parties.

Each role in the People aspect has its own corresponding responsibilities in executing project activities. These responsibilities are explained together with the activities conducted in the Process aspect, as outlined in the subsequent sections.

B. Process

The Process aspect consists of the phases to achieve the project objectives. The phases are Pre-Implementation, Preparation, Execution, and Post-Implementation. There are

ten factors identified in this aspect. These are explained in the following sections according to phase sequence.

1) Pre-Implementation

The Pre-Implementation phase contains the activities executed as the preparation to start a project. Four contributing factors are identified in this phase, namely Needs Identification, Project Planning, Vendor Selection, and Contract Establishment.

Need Identification consists of three elements to justify the need for implementing testing outsourcing projects. The elements are Identify Outsourcing Reasons, Identify Outsourcing Purpose, and Understanding of Outsourcing. The first element suggests that the client has to be clear about the reasons for conducting test outsourcing. This is crucial to ensure that the decision bring more benefits compared to in-house testing. The client does the analysis by assessing its resources, knowledge and cost. For the second element, the client should comprehend the purpose of pursuing test outsourcing. The client should ensure that such projects would fulfill their strategic objectives. Next, the client must understand the project needs. For example, they must be aware of the project's underlying strengths and limitations, to ensure that the project is executed smoothly. The Project Manager plays an important role in identifying these needs.

After the decision to execute testing outsourcing has been determined, a plan is needed to cover the essentials of the project. This is categorised as the Project Planning factor. Nine elements are identified in this factor, which are Define Goal and Objectives, Determine Schedule, Specify Infrastructure, Specify Strategy for Risks, Determine Scope of Work, Determine Human Resources, Allocate Cost, Specify Test Priority, and Specify Test Parts. The Project Manager is responsible for preparing the identified elements. To identify the project goal and objectives, the Project Manager has to analyse the project needs or any weaknesses in the testing process. The Project Manager also needs to consider the time differences of the participating parties, as well as determine the task workload and project schedule. The project infrastructure also needs to be specified. This includes the connectivity and network, information security, version control and digital or physical storage setup. Besides that, a risk assessment needs to be carried out. This is important to determine the possibly occurring risks and prepare a backup plan in advance. In terms of the work scope specification, the Project Manager could determine it based on the level of software development. Human resources could be determined based on the project size and duration. In implementing such a project, planning for accurate cost allocation is important. The Project Manager should know the methods of charging the testing services, for example, whether using conventional pricing methods or based on specific testing types. Next, specifying the task priorities is also essential in Project Planning. This could be done via evaluating risks, budget required or time constraints for specific test parts. The types of test to be outsourced could be decided based on three aspects, which are testing levels, testing types, and testing activities.

The Vendor Selection factor contains eight elements that need to be taken into consideration in selecting the appropriate testing vendor. The elements are Specify Needed Technical Skills, Specify Required Domain Knowledge, Ascertain Recognisable Reputation, Ascertain Low Turnover Rate, Specify Sufficient Human Resources, Identify Stable Political Status, Specify Language Compatibility, and Specify Culture Compatibility. The Project Manager has to make sure that the vendor has the required technical skills and domain knowledge according to the project needs. The vendor should also have low turnover rate. This information could be acquired by evaluating the vendor's past project history and their turnover rate information in the proposal. Besides that, the vendor should also have a recognisable reputation in the field. This could be determined based on their performance, expertise or accredited testing certifications. The vendor should also have sufficient human resources. The Project Manager could determine this matter based on the workload and the scope of work required. Next action is to ensure the political stability in the vendor's organisation and country. In terms of organisation, the Project Manager should consider whether or not the vendor has a good administrative bureaucracy. The vendor's country must also be in a good political state to ensure that the project is carried out feasibly and viably for a set period of time. The language compatibility between both parties should also be determined. Hence, the Project Manager could make preliminary interactions with the vendor, for example, via telephone or in person to ensure that the language used will not be an obstacle for further cooperation. Lastly, culture compatibility is also important in the Vendor Selection factor. The Project Manager could visit the vendor's organisation as a preliminary step to evaluating culture compatibility.

The selection of vendors enables the establishment of a contract. The contract acts as a guarantee for both parties to achieve their respective project objectives successfully. The next factor, which is the Contract Establishment, contains three elements of contract characteristics. The elements are Construct Comprehensive Content, Open to Negotiation, and Align with Project Needs and Plan. First of all, the contract should be as comprehensive as possible. Among the identified necessities for a comprehensive contract are scope of work, objectives, cost, statement of work, schedule, work authority, disclaimer, and intellectual asset rights. Both the Project Manager and vendor representative are responsible for making sure that every detail has been mentioned clearly and correctly. The contract should also be made open for negotiation. This is because there might be some changes that need to be done to achieve the project objectives. For example, the required testing technology or tools might change throughout the process. However, the changes should only be limited to the execution process without altering the contract's content. The contract should also be aligned with the project needs and plan. It is important to state the project milestones and the required resources specifically and clearly in order to achieve the objectives.

2) Preparation

The preparation phase consists of activities that need to be set up before the testing process can take place. Two contributing factors were identified, namely Infrastructure Setup and Testing Needs Setup. The Infrastructure Setup consists of four elements that must be set in advance. The elements are Install Network and Connectivity, Install Information Security, Setup Version Control, and Setup Digital or Physical Storage. Both the Test Team and Project Team are responsible for preparing the elements in this factor.

Firstly, because outsourcing might require communication across countries, the network must be built as the connection medium. The network should be developed according to the

standards that have been set. Via the network, channels of communication such as emails, virtual meetings, phone calls or instant messaging can be applied. A specified team to configure and supervise the network and channels should also be provided. The information shared between both parties must also be protected. Therefore, it is important to make sure that security measures are taken. This includes providing password security policies, establishing procedures for granting and revocation access, implementing firewall granting, and using a virtual private network.

Besides that, the Project Team should set version control systems in advance. The client carries out software development in versions. Various versions are forwarded to the Test Team to prepare the test materials and conduct the tests. The versions thus need to be properly captured and controlled. In addition, the valuable intellectual materials involved throughout the process needs to be kept appropriately. This includes digital storage for storing testing artefacts and physical materials such as documents and hard drives. For physical storage, the Test Team should provide a specific room to store these materials. The room should be accessed limited to only certain employees and only for a specific time period.

The next factor is the Testing Needs Setup. This provision is essential to guide and facilitate the testing process and must be prepared before the testing process takes place. The elements are Develop Test Plan, Develop Test Design, and Determine Test Tools and Procedure. The Test Team is responsible for preparing and handling the required materials. To develop the test plan, the Test Team's leader should have a clear understanding of the test process, so as to utilise the available resources for the project. For the test design development, the Test Team should have a better understanding of the software requirements to determine the correct actions that should be executed. Besides that, the preferred test tools and procedure also need to be determined. The Test Team could propose testing tools based on proven performance. In terms of procedure, using a checklist will be beneficial in order to ensure that each step is followed.

3) Execution

The execution phase is when the testing activities take place. This phase consists of one factor, Testing Execution, which is undertaken by the Test Team. There are four elements in this factor, which are Control Test Process, Fulfill Test Criteria, Adopt Testing Efficiency Strategy, and Report Testing Status.

The testing process could be controlled through direct observation of the testing progress. For example, the test results should be evaluated. This includes using metrics or collected data so that any necessary corrective actions could be taken. Moreover, each stage in the testing process has certain criteria that need to be defined, documented and signed by the stakeholders. Therefore, to ensure that the testing criteria are met, the Test Team needs to be clear about the components, modules or structures of the software being tested. The testers should also adopt efficient testing strategies to increase the rate of defect discovery and optimise time usage. For example, a tracking and logging mechanism could be used [42]. The testing process should be reported, whether it be in written or verbal form. To do so, the testers need to have good writing skills to report the test results analysis and have good communication skills to convey the information, if required.

4) Project Monitoring

The Project Monitoring factor comprises the ongoing effort conducted to track activities during the Preparation and Execution phases. The Project Manager handles project monitoring. There are four elements identified in this factor, which are Conduct On-Going Discussions, Tracking the Project Progress, Visit Regularly, and Allocate on-site Representative.

Firstly, regular discussions could be conducted by setting up compulsory meetings. Besides that, project progress must also be tracked. To do so, the Project Manager could make regular phone calls with the vendors or request current project reports for updates. The client's representative is also advised to conduct regular visits. The representative should visit the vendor's workplace, preferably at the beginning of the project or as needed, especially when involving different countries.

Besides that, the client's representative should be located at the vendor's organisation. The representative should be placed according to the project requirements or based on the organisation's geographical location. In terms of project requirements, the placement of the representative may be required in the initial stages of testing process. This makes transferring of knowledge easier and more readily accepted because it occurs directly. In terms of geographical location, the representative's placement may be needed for organisations that are located too far from each other. Through the presence of a representative, the project could be monitored closely, as the project progress might be disrupted by the different time zones among countries.

5) Post-Implementation

The Post-Implementation phase consists of activities that are executed towards the end of the project. There are two factors involved, which are Testing Evaluation and Project Close-Out. Both the Project Manager and Test Team play an important role in this phase.

Testing Evaluation is carried out to ensure that the test results achieve the targeted test objectives. There are four elements involved in this factor, which are Assess Passed Test, Report Final Test Results, and Evaluate Test Results. For the first element, the Test Team could assess the passed test by analysing data from the targeted test records and comparing them with the passed test obtained [43]. The assessment is beneficial to determine whether any follow-up actions are required, such as the need to modify the designed pass criteria. The Test Team will then use the assessment results to develop the final report for the project stakeholders. The final test report should contain detailed testing information, such as the comparison of test results, list of defects found, defects analysis and any problems identified during the test execution. For the third element, the Project Manager should evaluate the reported test results. The assessment could be made according to the compliance of the test objectives and requirements that have been set. Examples of the evaluation are the time of execution and the number of test cases that have passed and failed.

The last factor is Project Close-Out. This factor consists of two elements, which are Conduct Test Closure Activities and Evaluate Vendor Performance. Test Closure Activities are conducted by the Test Team, which comprise activities such as returning the test materials back to the client, checking whether or not the test was done according to plan, ensuring that the incident report is completed, and generating lessons learned for future reference [43].

For the second element, the Project Manager is responsible to evaluate the Test Team's performance. This is important for future projects. Among the criteria that are considered for this assessment are the efficiency to complete the tasks and the time taken by the testers to complete the testing tasks.

VI. Conclusion and Future Work

This paper has discussed the contributing factors that influence the success of software testing outsourcing projects. The factors were gathered and confirmed through a series of studies. The contributing factors were first collected from a theoretical study, which were then summarised as the model concept [16]. Based on the model concept, interview questions were designed and interviews with practitioners in the testing industry were conducted [17]. The theoretical and empirical results were analysed to develop the proposed framework for managing software testing outsourcing projects. Later, several experts who are experienced in software testing outsourcing projects were interviewed to confirm the feasibility and accuracy of the proposed framework.

Through experts' reviews and validation, this study has finalised fourteen factors, which form the basis of the framework. The factors are categorised into two aspects, namely People and Process. The People aspect consists of four factors, which are Top Management, Project Manager, Test Team, and Project Team. Each executer in the People aspect must possess certain elements or characteristics to conduct activities in software testing outsourcing projects.

In the Process aspect, there are four phases, which are classified according to the sequence of implementation. These phases are Pre-Implementation, Preparation, Execution, and Post-Implementation. Four factors are identified in the Pre-Implementation phase, which are Needs Identification, Project Planning, Vendor Selection, and Contract Establishment. On the other hand, the Preparation phase consists of Infrastructure Setup and Testing Needs Setup factors. Next, the Execution phase consists of the Testing Execution factor. The Project Monitoring factor must be done during the Preparation and Execution phases. Lastly, the Post-Implementation phase consists of two factors, which are Testing Evaluation and Project Close-Out.

The framework can be used to guide practitioners in the testing industry to manage testing outsourcing projects, for Government or Private sectors, and for both client and vendor. Besides that, the framework can be used as a reference for future research in the domain.

Several further efforts can be suggested to strengthen the work. For example, each factor in this study only delineates the elements involved in general. The elements could be refined in more detail according to specific operational terms. Besides that, the framework could be further validated via case study. This framework was developed based on previous research, practitioners' views and experts' validation, which are mainly retrospective. Therefore, further research should test the feasibility of the proposed framework in the actual settings of software testing outsourcing projects.

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